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IS 11298-3-5 to 7 (1998): Plastic films for electrical purposes, Part 3: Specifications for individual materials, Section 5-7: Requirements for Polyimide Films Used for Electrical Insulation [ETD 2: Solid Electrical Insulating Materials and Insulation Systems]



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“Knowledge is such a treasure which cannot be stolen”

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IS 11298 (Part 3/Sec 5 to 7) : 1998
IEC 674-3-4 to 6 (1993)

भारतीय मानक

(Reaffirmed 2004)

विद्युत प्रयोजनों के लिए प्लास्टिक फिल्म

भाग 3 अलग-अलग सामग्रियों की विशिष्टियाँ

अनुभाग 5-7 पॉलीमाइड फिल्म की अपेक्षाएँ

Indian Standard

PLASTIC FILMS FOR ELECTRICAL PURPOSES

PART 3 SPECIFICATIONS FOR INDIVIDUAL MATERIALS

Sections 5 to 7 Requirements for Polyimide Films Used for Electrical Insulation

ICS 29.035.20 : 83.140.10

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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NATIONAL FOREWORD

This Indian Standard which is identical with IEC 674-3-4 to 6 (1993) 'Specification for plastic films for electrical purposes — Part 3 : Specifications for individual materials — Sheets 4 to 6 : Requirements for polyimide films used for electrical insulation' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Solid Electrical Insulating Materials Sectional Committee (ETD 02) and approval of the Electrotechnical Division Council.

This standard (Part 3/Sec 5 to 7) is one of the series of Indian Standards which deals with plastic films for electrical purposes. The series consists of the following parts:

Part 1 Definitions and general requirements

Part 2 Methods of test

Part 3 Individual materials — Specifications

This standard (Part 3/Sec 5 to 7) covers the requirements for polyimide films for use as electrical insulation.

In this Indian Standard the following International Standards are referred to. Read in their respective places the following :

<i>International Standard</i>	<i>Indian Standard</i>
IEC 674-1 : 1980	11298 (Part 1) : 1985
IEC 674-2 : 1988	11298 (Part 2) : 1987
IEC 757 : 1983 Code for designation of colour	There is no equivalent Indian Standard at present
IEC 674-3-4 (or 5 to 6)	11298 (Part 3/Sec 5 or 6 or 7) 'For designation of film'

Certain conventions appearing in this dual number standard are not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- Comma (,) has been used as a decimal marker while in Indian Standard, the current practice is to use a point (.) as the decimal marker.

Only the English language text in the IEC standard has been retained while adopting it in this Indian Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PLASTIC FILMS FOR ELECTRICAL PURPOSES

PART 3 SPECIFICATIONS FOR INDIVIDUAL MATERIALS

Sections 5 to 7 Requirements for Polyimide Films Used for Electrical Insulation

1 General

1.1 Scope

This International Standard gives the requirements for the following polyimide, films with or without heat sealable fluoroethylene-propylene (FEP) coatings.

Sheet 4: Requirements for polyimide films based on poly(N,N'-p,p'-oxydiphenylene pyromellitimide).

Sheet 5: Requirements for polyimide films based on poly(N,N'-p-phenylene biphenyl tetra carboxylimide).

Sheet 6: Requirements for polyimide films based on poly(N,N'-p,p'-oxydiphenylene biphenyl-tetracarboxylimide).

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 674-1: 1980, *Specification for plastic films for electrical purposes - Part 1: Definitions and general requirements.*

IEC 674-2: 1988, *Specification for plastic films for electrical purposes - Part 2: Methods of test.*

IEC 757: 1983, *Code for designation of colours.*

1.3 Classification

The polyimide film shall be of the following types:

Type 1: General purpose

Type 2A: One side coated*

Type 2B: Two sides coated*

* Type 2 is surface coated to render the surface(s) heat sealable.

Type 3: Dimensionally stabilized (only generally available in sheets 4 and 5 types)

Type 4: Heat shrinkable (only generally available in sheet 4 types)

2 Designation

The film shall be identified by the designation which follows:

Designation of the film – IEC 674-3-4 (or 5, or 6) – PI – type – thickness in micrometres – width in millimetres – length in metres – colour.

Example:

Polyimide film IEC 674-3-4 – PI – type 1 – 100 – 20 – 200 – nc – f
(f = flame retardant; r = regular; nc = natural colour; other colours according to IEC 757).

3 General requirements

Type 1 material shall be a flexible, self-supporting film made from polyimide polymer.

Type 2 shall have a heat sealable coating of fluoroethylene-propylene (FEP) resin on one or both sides of type 1 material.

Type 3 shall be identical to type 1 except for improved dimensional stability.

Type 4 shall be identical to type 1 except for the heat shrinkability requirement.

All types shall conform to the general requirements laid down in IEC 674-1.

4 Dimensions

4.1 Thickness

The film thickness of types 1, 3 and 4 shall be measured by a gravimetric method in accordance with 3.3 of IEC 674-2. The thickness of type 2 shall be measured using a micrometer in accordance with 3.1 of IEC 674-2.

The overall thickness shall be in accordance with the nominal thickness and permitted range of thickness given in table 1 and 2.

Table 1 – Nominal thickness and permitted range of thicknesses
for types 1, 3 and 4 (in μm)

Nominal thickness	Actual thickness		
	Limit	Sheet 4	Sheets 5 and 6
7,5	Max. Min.	9 6	8,5 6,5
13*	Max. Min.	15,2 10,2	13,5 11,5
20	Max. Min.	– –	22 18
25	Max. Min.	29 22	27 23
40	Max. Min.	– –	44 36
50	Max. Min.	57 44	54 46
75	Max. Min.	83 69	81 69
100	Max. Min.	– –	107 93
125	Max. Min.	136 118	133 117

The dash "-" indicates that these sizes are not generally available.
* Some manufacturers quote a nominal thickness of 12,5 μm in place of the 13 μm used in the above table. Conformance with this standard indicates that such material meets the requirements, described in the above-mentioned table under the heading 13 μm .

Table 2 – Nominal thickness and overall permitted range of thicknesses
for type 2 (in μm)

Types	Nominal thickness				Overall permitted range of thicknesses			
	Nominal thickness μm	First FEP* layer μm	Polyimide layer μm	Second FEP* layer μm	Sheet 4		Sheets 5 and 6	
					Min.	Max.	Min.	Max.
2A	25	None	13**	13**	19	31	20	30
2A	38**	None	25	13**	31	44	33,5	41,5
2A	50	None	25	25	42	58	46	54
2A	63**	None	50	13**	55	71	58,5	66,5
2A	75	None	50	25	65	85	70	90
2A	100	None	50	50	90	110	90	110
2A	100	None	75	25	90	110	90	110
2A	150	None	125	25	110	160	140	160
2B	30	2,5	25	2,5	26	34	26	34
2B	38**	13**	13**	13**	30	45	30	45
2B	50	13**	25	13**	42	58	46	54
2B	75	13**	50	13**	65	85	70	90
2B	125	25	75	25	110	140	110	140

* Fluoroethylene-propylene.

** Some manufacturers quote nominal thicknesses of 12,5 μm , 37,5 μm and 62,5 μm in place of the 13 μm , 38 μm and 63 μm , respectively, used in the above table. Conformance with this standard indicates that such material meets the requirements, described in the above-mentioned table under the headings of 13 μm , 38 μm and 63 μm , respectively.

4.2 Width

The film width shall be measured in accordance with the requirements of clause 5 of IEC 674-2.

Preferred widths cannot be given on account of the great variety of applications.

The maximum deviation in film width from the nominal shall be as given in tables 3A and 3B unless otherwise specified in the purchase contract.

Table 3A – Tolerance on slit width for sheet 4 material

Slit width range mm	Tolerance mm
Less than 26	$\pm 0,4$
26 to 102	$\pm 0,8$
Greater than 102	$\pm 1,6$

Table 3B – Tolerance on slit width for sheets 5 and 6 material

Slit width range mm	Tolerance mm
≤ 25	$\pm 0,2$
$> 25 - 50$	$\pm 0,3$
$> 50 - 100$	$\pm 0,5$
$> 100 - 300$	$\pm 1,0$
$> 300 - 500$	$\pm 2,0$
> 500	$\pm 2,0$

5 Properties

5.1 Properties not dependent on thickness*

Table 4 – Requirements for all types

Property	Requirements			Unit	IEC 674-2 Test method	Types where available
	Sheet 4	Sheet 5	Sheet 6			
Density	$1\,425 \pm 10$	$1\,480 \pm 10$	$1\,390 \pm 10$	kg/m ³	4, method D ¹⁾	1, 3, 4
Melting point	Does not melt ⁴⁾	Does not melt ⁴⁾	Does not melt ⁴⁾			1, 2, 3, 4
Permittivity	$3,5 \pm 0,4$ $3,4 \pm 0,4$	$3,5 \pm 0,4$ $3,4 \pm 0,4$	$3,5 \pm 0,4$ $3,4 \pm 0,4$	–	16.1 ²⁾ (23 °C, 48 Hz – 62 Hz) (23 °C, 1 kHz)	1, 3, 4
Dissipation factor	$\leq 4,0 \times 10^{-3}$	$\leq 5,0 \times 10^{-3}$	$\leq 5,0 \times 10^{-3}$	–	16.1 ²⁾ 23 °C, 1 kHz or 48 Hz – 62 Hz	1, 2, 3, 4
Volume resistivity	$\geq 1 \times 10^{10}$	$\geq 1,0 \times 10^{13}$	$\geq 1,0 \times 10^{13}$	$\Omega \cdot m$	15.1 ³⁾	1, 2, 3, 4
Surface resistivity	$\geq 1 \times 10^{14}$	$\geq 1,0 \times 10^{16}$	$\geq 1,0 \times 10^{16}$	Ω	14 ³⁾	1, 2, 3, 4
Dimensional stability (shrinkage in MD and TD) ⁵⁾	$\leq 0,35$	$\leq 0,2$	$\leq 0,2$	%	23, 150 °C, $\geq 25 \mu m$	1
	$\leq 2,50$	$\leq 1,0$	$\leq 3,0$	%	23, 400 °C, $\geq 25 \mu m$	2
	$\leq 0,05$	$\leq 0,04$	–	%	23, 200 °C, $\geq 25 \mu m$	3
	$\leq 5,0$	–	–	%	23, 200 °C, $\geq 25 \mu m$	4
Moisture absorption	$\leq 4,0$	$\leq 2,0$	$\leq 2,0$	%	30, 6 h	1, 2, 3, 4

* There are no requirements for type 2 for density and permittivity since they are highly dependent on the relative thickness of PI and FEP.

1) The recommended mixture is carbon tetrachloride/n-heptane.

2) Use non-contacting electrodes or evaporated metal electrodes.

3) To be measured at 200 °C \pm 5 K, after exposure to 200 °C for 1 h.

4) For type 2, the FEP coating shall melt.

5) MD: machine direction; TD: transverse direction.

5.2 Properties dependent on thickness

Table 5 – Property values

Nominal thickness μm	Property	Tensile strength, both machine and transverse directions, min. value			Elongation at break both machine and transverse directions, min. value			A.C. electric strength, 48 Hz to 62 Hz		
	Unit	MPa			%			V/ μm		
	IEC 674-2 Test method Clause	10°			10°			18.1 Using 6 mm diameter electrodes in air		
	Applicability	Sheet 4 Types 1, 3, 4	Sheet 5 Types 1, 3	Sheet 6 Type 1	Sheet 4 Types 1, 3, 4	Sheet 5 Types 1, 3	Sheet 6 Type 1	Sheet 4 Types 1, 3, 4	Sheet 5 Types 1, 3	Sheet 6 Type 1
7,5		110	133	110	25	6	25	120	150	150
13		138	176	138	35	8	40	120	150	150
20		–	294	196	–	25	80	–	200	200
25		165	294	196	40	25	80	235	200	200
40		–	294	196	–	25	80	–	180	195
50		165	294	196	45	25	80	195	180	195
75		165	294	196	50	25	80	175	130	135
100		–	294	196	–	25	80	–	110	110
125		165	294	196	50	25	80	120	95	110

* Rate of extension 50 mm/min, reference lines 100 mm apart.
The dash "–" indicates that these sizes are not generally available.

Table 6 – A.C. electric strength for type 2

Types	Nominal overall thickness ¹⁾ μm	Minimum electric strength		IEC 674-2 Test method subclause
		Sheet 4 V/ μm	Sheets 5 and 6 V/ μm	
2A	25	120	120	18.1 Using 6 mm diameter electrodes in air
2A	38	140	130	
2A	50	120	120	
2A	63	100	110	
2A	75	100	100	
2A	100 ²⁾	80	80	
2A	100 ³⁾	105	110	
2A	150	85	85	
2B	30	155	130	
2B	38	120	120	
2B	50	120	120	
2B	75	100	100	
2B	125	85	85	

¹⁾ See table 2, for nominal thickness of PI and FEP layers.
²⁾ FEP coating is 50 μm nominal thickness.
³⁾ FEP coating is 25 μm nominal thickness.

5.3 Other properties

5.3.1 Thermal endurance

The thermal endurance shall be measured in accordance with the requirements of clause 28 of IEC 674-2.

The end point criterion shall be 50 % retention of the original tensile strength value.

The temperature index shall be:

- for material conforming to sheet 4 – not less than 200;
- for material conforming to sheets 5 and 6 – not less than 220.

The recommended ageing temperatures are:

- for material conforming to sheet 4 – 275 °C, 300 °C and 325 °C;
- for material conforming to sheets 5 and 6 – 300 °C, 325 °C and 350 °C.

The water content of the air in the ageing oven during the ageing process shall be in the range of 9,5 g/m³ to 12,5 g/m³, equivalent to 50 % ± 5 % relative humidity at (23 ± 2) °C.

This test need not be repeated unless the manufacturer has made a significant change in the composition or method of production of the material.

5.3.2 Burning characteristics

When determined according to clause 29 of IEC 674-2, the classification shall be VTF 0.

5.3.3 Hydrolytic stability

Under consideration.

5.3.4 Radiation resistance

Under consideration.

5.3.5 Surface discharge resistance

Under consideration.

6 Roll characteristics

6.1 Roll diameter

This material is sold by weight. Preferred outside roll diameters are 124 mm (not for sheet 4 types), 152 mm, 241 mm, 280 mm and 356 mm dependent on the nominal film thickness, core size and user requirements. The tolerance on these diameters is 6,4 mm.

Approximate expected roll lengths are given in tables 7 and 8.

Table 7 – Approximate expected roll lengths (m) for
– sheet 4 types 1, 3 and 4
– sheet 5 types 1 and 3
– sheet 6 type 1

Roll dimensions mm		Applicability	Nominal thickness µm								
Core ID	Roll OD		7,5	13	20	25	40	50	75	100	125
76	124	Sheet 4	–	–	–	–	–	–	–	–	–
		Sheets 5 and 6	720	–	–	–	–	–	–	–	–
76	152	Sheet 4	–	910	–	460	–	230	150	–	91
		Sheets 5 and 6	–	910	570	450	280	230	150	–	–
76	241	Sheet 4	–	–	–	1 550	–	780	520	–	300
		Sheets 5 and 6	–	–	1 880	1 500	940	750	500	380	300
152	241	Sheet 4	2 870	1 830	–	910	–	460	300	–	180
		Sheets 5 and 6	*	*	1 140	910	570	460	300	230	180
152	280	Sheet 4	–	–	–	1 550	–	780	520	–	300
		Sheets 5 and 6	*	*	1 880	1 500	940	750	500	380	300
152	356	Sheet 4	–	–	–	–	–	1 520	1 040	–	610
		Sheets 5 and 6	–	–	–	–	–	1 500	1 000	760	600

The dash "–" indicates that these sizes are not generally available.
* Maximum length 1 000 m.

Table 8 – Approximate expected roll lengths (m) for type 2

Roll dimensions mm		Applicability	Type 2A Nominal thickness µm							Type 2B Nominal thickness µm				
Core ID	Roll OD		25	38	50	63	75	100	150	30	38	50	75	125
76	152	Sheet 4	460	310	230	190	160	110	78	–	320	230	160	90
		Sheets 5 and 6	460	300	230	190	150	110	78	380	300	230	150	90
76	241	Sheet 4	–	1 040	780	680	520	380	280	–	–	780	520	300
		Sheets 5 and 6	–	1 000	750	640	500	380	280	1 300	1 000	750	500	300
152	280	Sheet 4	–	1 040	–	–	–	380	280	–	–	–	–	300
		Sheets 5 and 6	–	1 000	750	640	500	380	280	1 300	1 000	750	500	300

The dash "–" indicates that these sizes are not generally available.

6.2 Windability/sag

Sheet 4 types: there is no requirement for film widths less than 300 mm and film thicknesses of less than 25 μm .

Sheet 5 and 6 types: there is no requirement for film widths less than 300 mm and film thicknesses of less than 20 μm .

The sag shall be measured in accordance with the requirements of 6.3, method A, of IEC 674-2.

The sag, at a tension of 2,8 MN/m² shall be less than or equal to 19 mm.

6.3 Joins

Where joins (splices) are permitted, their construction shall conform to the requirements given in 3.3 of IEC 674-1. Breaks (unjoined pieces) shall also be indicated so as to be clearly visible when viewed from the end face of the roll.

The number of joins or breaks in each roll shall not exceed the values given in tables 9 and 10.

Table 9A – Maximum permissible number of joins per roll for:

- sheet 4 types 1, 3 and 4
- sheet 5 types 1 and 3
- sheet 6 type 1

Roll dimensions		Applicability	Nominal thickness								
mm			µm								
Core ID	Roll OD		7,5	13	20	25	40	50	75	100	125
76	124	Sheet 4	-	-	-	-	-	-	-	-	-
		Sheets 5 and 6	4	-	-	-	-	-	-	-	-
76	152	Sheet 4	-	5	-	2	-	1	1	-	1
		Sheets 5 and 6	-	4	2	2	1	1	1	-	-
76	241	Sheet 4	-	-	-	7	-	5	4	-	4
		Sheets 5 and 6	-	-	5	5	4	4	3	3	3
152	241	Sheet 4	30	11	-	-	-	-	-	-	-
		Sheets 5 and 6	*	*	3	3	2	2	2	2	2
152	280	Sheet 4	-	-	-	7	-	5	4	-	4
		Sheets 5 and 6	*	*	5	5	4	4	3	3	3
152	356	Sheet 4	-	-	-	-	-	11	9	-	9
		Sheets 5 and 6	-	-	-	-	-	7	5	5	5

The dash "-" indicates that these sizes are not generally available.

* Maximum number of joins 5/1 000 m.

Table 9B – Minimum permissible distance between splices and between any splice and the end of the roll (m) for:
– sheet 4 types 1, 3 and 4
– sheet 5 types 1 and 3
– sheet 6 type 1

Roll dimensions mm		Applicability	Nominal thickness µm								
Core ID	Roll OD		7.5	13	20	25	40	50	75	100	125
76	124	Sheet 4	–	–	–	–	–	–	–	–	–
		Sheets 5 and 6	–	–	–	–	–	–	–	–	–
76	152	Sheet 4	–	30	–	30	–	30	30	–	22
		Sheets 5 and 6	–	50	150	150	100	30	30	30	30
76	241	Sheet 4	–	–	–	30	–	30	30	–	22
		Sheets 5 and 6	–	–	150	150	100	30	30	30	30
152	241	Sheet 4	–	30	–	30	–	30	30	–	22
		Sheets 5 and 6	*	*	150	150	100	30	30	30	30
152	280	Sheet 4	–	30	–	30	–	30	30	–	22
		Sheets 5 and 6	*	*	150	150	100	30	30	30	30
152	356	Sheet 4	–	–	–	–	–	30	30	–	22
		Sheets 5 and 6	–	–	–	–	–	30	30	30	30

The dash "–" indicates that these sizes are not generally available.
* Minimum distance 50 m in a 1 000 m roll.

Table 10A – Maximum number of permissible joins per roll for type 2

Roll dimensions mm		Applicability	Type 2A Nominal thickness µm							Type 2B Nominal thickness µm				
Core ID	Roll OD		25	38	50	63	75	100	150	30	38	50	75	125
76	152	Sheet 4	5	3	2	2	2	–	–	–	3	2	2	–
		Sheets 5 and 6	5	3	2	2	2	1	–	3	5	2	2	1
76	241	Sheet 4	–	8	7	5	5	5	4	–	–	7	6	5
		Sheets 5 and 6	–	4	4	4	4	4	3	4	–	4	4	4
152	280	Sheet 4	–	8	–	–	–	5	4	–	–	–	–	5
		Sheets 5 and 6	–	4	–	–	–	4	4	4	–	–	–	4

The dash "–" indicates that these sizes are not generally available.

Table 10B – Minimum permissible distance between splices and between any splice and the end of the roll (m)

Roll dimensions mm		Applicability	Type 2A Nominal thickness µm							Type 2B Nominal thickness µm				
Core ID	Roll OD		25	38	50	63	75	100	150	30	38	50	75	125
76	152	Sheet 4	30	30	30	30	30	-	-	-	30	30	30	22
		Sheets 5 and 6	30	30	30	30	30	30	-	30	30	30	30	30
76	241	Sheet 4	-	30	30	30	30	22	22	-	-	30	30	22
		Sheets 5 and 6	-	30	30	30	30	30	30	-	30	30	30	30
152	280	Sheet 4	-	30	-	-	-	22	22	-	-	-	-	22
		Sheets 5 and 6	-	30	-	-	-	30	30	30	-	-	-	30

The dash "-" indicates that these sizes are not generally available.

6.4 Roll width

The maximum difference between the film width measured according to clause 5 of IEC 674-2 and the roll width excluding the core expressed in millimetres shall be according to table 11.

Table 11 – Maximum difference between the film width and the roll width

Core ID ≤77 mm		Core ID >77 mm	
Roll outer diameter		Roll outer diameter	
≤241	>241	≤280	>280
3,2	6,4	3,2	6,4

6.5 Cores

Preferred core inside diameters are 76 mm and 150 mm.

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